## Pricing Credit Derivatives and Credit Securitization

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# Chapter 1

# Introduction

This thesis investigates credit derivatives and credit securitization markets, which were at the center of the 2007-2009 financial crisis. Credit derivatives are instruments designed to transfer credit risk of the underlying assets between financial institutions, which facilitates risk sharing and should thus lead to more efficient capital allocation. The most important credit derivatives are credit default swaps (CDS). They are single-name instruments that are in essence simple insurance contracts protecting against losses associated with credit events of a corporate or a financial asset. The credit derivatives markets developed rapidly from the late 1990's until the start of the 2007-2009 financial crisis. Credit securitization is about pooling various types of debt or mortgages to create repackaged instruments with the purpose of selling them to investors. Increasingly popular prior to the 2007-2009 crisis were collateralized debt obligations (CDO), which are multi-name structured finance instruments that protect against losses associated with a portfolio of underlying assets rather than single-name assets.

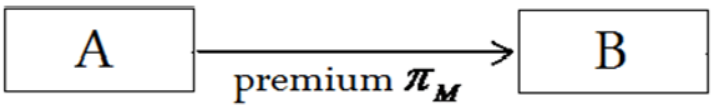
## 1.1 Credit Default Swaps

The history of credit default swaps dates back to 1994 when they were first used by JP Morgan (Financial Times, 2006). The market grew rapidly and the notional outstanding of CDSs reached $300 billion in 1998 and $3.8 trillion in 2003, while the record level of $62.2 trillion was reached by the end of 2007 according to ISDA (2010). The credit default swap market has also expanded in terms of assets used as underlying securities such that not only default risks of corporate, municipal or sovereign bonds could be insured. Market

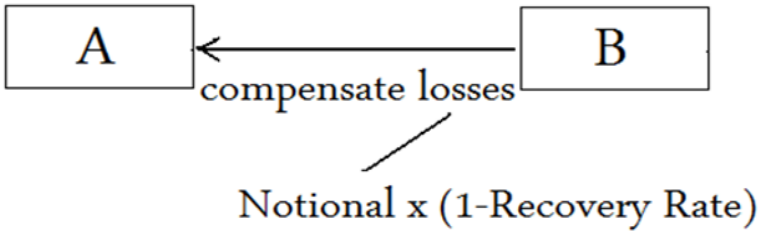
participants have begun using credit default swaps to transfer credit risk of corporate loans or even more complicated financial structures such as asset backed securities or tranches of CDOs.

The main advantage of credit default swaps is that they allow for transferring pure default risk in a simple and convenient manner that is unconstrained by the issuance and liquidity of underlying bonds or assets. Another advantage is that it facilitates taking short positions in credit risk, which is more complicated in bond markets or other markets for physical assets. Furthermore, bonds are most often less liquid than credit default swaps. That is partly because various bonds issued by the same entity have typically different characteristics along several dimensions, while credit defaults swaps are largely standardized. Moreover, from a modeling perspective, extraction of the pricing of credit risk from bond prices is dependent on the choice of the risk-free rate, while credit default swaps provide direct pricing of credit risk.

A credit default swap is a financial swap agreement between two parties whereby one party is as protection buyer (long position) and pays a periodic fee known as CDS premium to the other party known as protection seller (short position). The CDS contract stipulates that in exchange for receiving the periodic fee the protection seller is obliged to compensate the protection buyer for any losses associated with default or in some cases other credit events of the underlying obligor (reference obligation C). Graphically, the cash flows from a credit default swap between Party A (protection buyer) and Party B (protection seller) can be depicted as follows. Party A pays a periodic fee to Party B:




and if company C defaults or incurs another pre-specified credit event, then party B compensates party A for the loss given default on the notional of the CDS contract:




In practice, most credit default swaps are highly standardized. The most common maturity of CDSs is 5 years and the most common currency denomination is that of the geographic location of the underlying reference entity (e.g. USD for US companies). The typical trade notional is $5 million (Chen et al., 2011). Credit default swaps can differ in terms of the type of credit events triggering payments. Currently, the most common restructuring for North American markets is 'no restructuring' (only defaults trigger payments) and 'modified-modified restructuring' for European companies.

Credit default swaps have played an important role during the financial crisis. They have become a leading indicator of default risk present in the economy and particularity the risk of collapse of the banking sector and sovereign states. From the previously rather esoteric financial instruments, credit default swaps have become an indicator commonly quoted in the popular press. Probably the most reported CDS instrument was that on the Greek government debt, which in the beginning of 2012 was quoted at above the staggering 20,000 bps (based on Markit data). This was a clear indication that the market was expecting an imminent default, which did occur on March 9, 2012 (ISDA, 2012a). The credit default swaps have also been put into spotlight earlier when AIG has found itself on the brink of collapse being unable to post collateral on its massive positions in credit default swaps. AIG has accumulated $533 billion of CDS positions of which $79 billion were referencing mortgage backed securities (Financial Crisis Report, 2011). When the value of AIG's positions started to rapidly turn negative, the company could not meet margin calls for collateral and was effectively bankrupt. Due to the fear of contagion and the collapse of the financial system, the federal government has conducted the largest ever bailout of a private company, which in the case of AIG eventually totaled over $180 billion (Financial Crisis Report, 2011).

Credit default swap markets have developed as largely unregulated markets since they are over-the-counter markets dominated by large dealer banks and other financial institutions. The International Swaps and Derivatives Association has set up rules on how

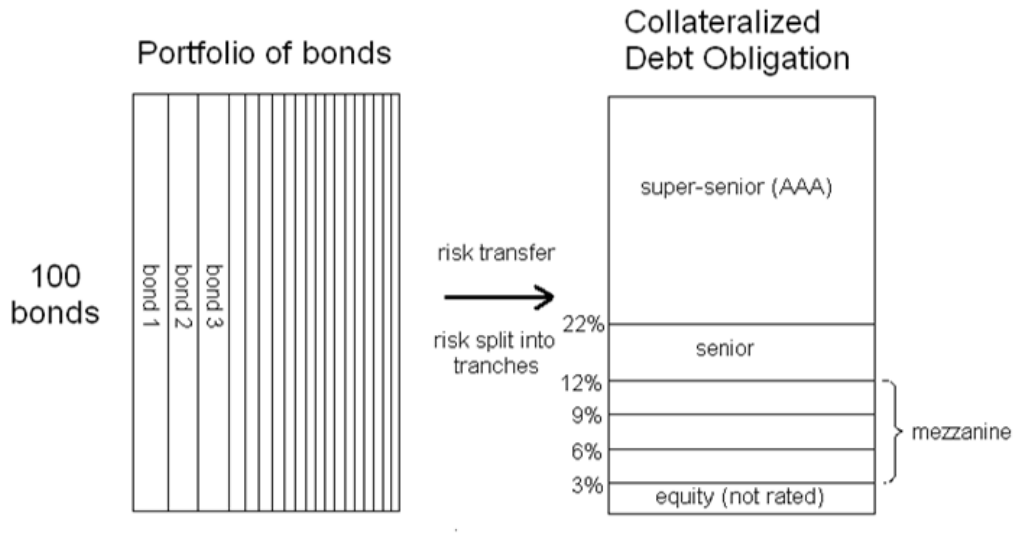
the CDS markets operate including many legal aspects of CDS contacts and various rules on what constitutes a default or how the recovery rates are determined. Since becoming mainstream financial instruments, credit default swaps have had both proponents and opponents holding very diverging views about how they should be regulated. For a detailed discussion on the topic see Stulz (2010). The proponents argued that CDS markets make it easier to transfer and trade credit risk, which improves efficient capital allocation and is thus beneficial to the economy. They also pointed out that credit derivatives make the economy more resilient because it leads to better risk sharing and allows banks to off-load risks to other investors. Alan Greenspan has argued in 2003 "that the growing array of derivatives and the related application of more-sophisticated methods for measuring and managing risks had been key factors underlying the remarkable resilience of the banking system, which had recently shrugged off severe shocks to the economy and the financial system" (Greenspan, 2005). However, years later he has admitted making a mistake in this statement with respect to credit default swaps (Reuters, 2008). The critiques of credit default swaps had concerns along several dimensions. First, the concerns were raised that credit default swaps have become extensively used for speculative purposes far beyond risk-hedging. In particular, the so-called empty creditor problem arises when bondholders have fully insured their exposure to default via credit default swaps and therefore become less willing to participate in a restructuring. In some cases they might even benefit from bankruptcy. Moreover, concerns have also been raised that credit default swaps can be used to take large short bets against companies, which can increase their CDS premia and thus not only increase borrowing costs of a company, but also lower their perceived creditworthiness in the eyes of other market participants. George Soros argues that large short positions in CDS markets can thus become self-validating and calls for banning naked shorting in this market (Soros, 2009). Similar arguments were used to motivate naked CDS bans by the European Union during the sovereign crisis although the validity of such arguments are disputed by many scholars and practitioners. Second, while the use of CDSs spreads the risks among many financial institutions, it may also have potential to create a systemic crisis when a large enough shock hits the economy. A major concern is counterparty risk since CDSs are not fully collateralized, but typically only a limited margin is maintained. There are also concerns that huge interconnectedness between financial institutions through CDSs can lead to a domino effect if a large party defaults although the markets have so far not experienced such a scenario.

The CDS markets have sustained its prominent role in the financial system throughout

and after the 2007-2009 financial crisis. Although the CDS notional outstanding have declined from a peak of over $60 trillion to about a half of that amount in 2010, the decline was largely attributable to trade compressions that eliminate unnecessary counterparty risk from the system (Economist, 2009). Trade compressions replace existing contracts with a new set of contracts that preserve net risk exposure, but with fewer contracts and less interconnectedness between different parties. This reduces counterparty risk because in the event of default of a major player in the market the amount of resulting payments are not dependent on the net CDS positions of a defaulted party, but its gross positions. Introducing trade compressions was one of the first moves that the industry has undertaken in response to the financial crisis. Another measure to further reduce counterparty risk was the gradual move towards central clearing although that was at the cost of creating systemic risk at the level of central counterparty clearing houses. The market participants have also introduced a number of standardization measures and settlement rules known as the CDS Big-Bang for North American markets and CDS Small-Bang for European markets. These measures standardized coupon levels and coupon payment dates and also facilitated handling defaulted CDSs via auctions among other changes. The regulators are also considering introducing obligatory trade reporting in the CDS markets to improve transparency, but due to concerns about adverse effect of such measures on liquidity provision by dealers they have been temporarily postponed.

## 1.2 Collateralized Debt Obligations

Collateralized debt obligations are sophisticated structured finance securities that transform portfolios of lower-rated assets into several new securities of varying credit quality known as CDO tranches. The credit risk of the collateral portfolio is split and sold to investors in tranches of CDOs. The tranche investors bear the losses incurred by the underlying portfolio within the pre-agreed percentage limits, according to a certain waterfall structure, and they are compensated for taking this risk with fixed premium payments. The figure below illustrates the structure of a typical CDO instrument. In the figure, the collateral portfolio consists of 100 bonds, while the CDO consists of six tranches. The tranche cut-off levels in this example are, respectively, 3%, 6%, 9%, 12%, 22% and 100% of the portfolio. The tranche at the bottom of the CDO in the figure is the most risky tranche known as the equity tranche and in return it offers the highest coupon. Investors




buying this tranche will incur losses upon the first default of any of the 100 bonds in the collateral portfolio. They will lose their entire investment as soon as the portfolio loss reaches 3%, which assuming recovery rate of 40% occurs after five of the bonds have defaulted. As we move up the water-fall structure of the CDO, each subsequent tranche is safer since a given tranche only incurs losses once all subordinate tranches are wiped out. The super-senior tranche is typically considered a very safe investment. In our example, it starts incurring losses once the portfolio loss rate reaches 22%, which assuming a 40% recovery rate would only occur after 37% of corporate bonds within the collateral pool defaults. For a well-diversified collateral portfolio such scenario would be equivalent to an economic catastrophe that has not occurred in any major economy in the post-war period. The super-senior tranche therefore obtains in most cases the highest AAA rating from the rating agencies, but it also offers the lowest coupon relative to the other tranches. Similarly, the senior tranche typically obtains an AA or AAA rating and is considered very safe as well. In our example it would start incurring losses when the portfolio loss rate exceeds 12% and it is fully wiped out when the loss rate reaches 22%.

The first CDO was created in 1987 at Drexel Burnham Lambert Inc., which was once a major investment banking firm (Cresci, 2005). In the beginning, CDOs were backed by corporate bonds, emerging market bonds or bank loans. The CDO markets started

growing rapidly around the year of 2000 when the annual issuance reached $68 billion and by 2006 it grew to over $500 billion (SIFMA, 2014). The array of securities used as collateral was expanding as well. The CDOs backed by high-yield bonds became very popular around the turn of the century although they suffered heavy losses during the dot-com bubble burst in 2001-02 and their issuance has never recovered (Benmelech and Dlugosz, 2009b). Mortgage-backed CDOs became dominant around 2004 when more than half of CDOs issued were backed by mortgages (Financial Crisis Report, 2011). These CDOs had collateral pools comprised of tranches of mortgage backed securities (MBSs). Along with the use of MBSs in the collateral pools, CDOs backed by subprime loans became popular. The industry also introduced CDO-squareds, which were CDOs backed by tranches of other CDOs. Other types of CDOs included CDOs backed by tranches of asset backed securities (ABS), which were based on other types of debt such as credit card debt or student loans. Another innovation was the creation of synthetic CDOs, which had collateral pools comprised of credit default swaps rather than physical assets such as bonds. This has given the market additional flexibility in choosing the collateral of preferred obligors because CDSs could always be created specifically for the purpose of issuing CDOs regardless of the availability of the underlying physical asset.

The process of creating CDOs was largely unregulated by the government. However, the complexity of most CDOs implied that even institutional investors such as pension funds or mutual funds were unable to independently assess the risks of CDOs. Therefore the market practice was that CDO tranches were rated by one or two of the major rating agencies (S&P, Moody's or Fitch). The rating agencies have devised rating models to assess the risks of CDOs, which were built on the standard Gaussian factor copula approach to modeling joint defaults introduced by Li (2000). The rating agencies would analyze the collateral pools to determine default probabilities of the underlying assets and the correlations between their defaults. The model and assumptions of the rating agencies were publicly disclosed, which means that the originators of CDOs knew how to optimally choose collateral pools and CDO structures to maximize their gains. In practical terms, the rating agencies were thus acting as regulators of the market and they were setting up the rules on which structures and collaterals were deemed appropriate for creating highly rated CDO tranches.

Collateralized debt obligations became very popular in the period preceding the 2007-09 financial crisis because they offered higher coupons compared to similarly-rated corporate bonds or other assets. That period was characterized by historically low interest rates,

which meant that pension funds, asset managers or mutual funds were very eager to boost their returns. In light of the rating-based restrictions imposed either by governmental regulations or self-mandated, CDOs were the most convenient way of boosting returns on highly rated assets, typically AA or AAA rated. In other words, manufacturing CDO tranches filled the insatiable demand for safe assets of which the natural supply was limited as pointed out by Caballero (2010) and at the same time investing in CDOs allowed investors to enjoy higher yields.

The demise of collateralized debt obligations during the 2007-09 financial crisis was severe and abrupt. The crisis was precipitated by poor performance of the US subprime mortgage debt when default rates in this segment started rising. The ensuing loss of confidence resulted in large price declines of many of these securities including those initially rated AAA, which shocked investors and spread panic throughout the financial system. The confidence in the broader CDO sector was undermined and massive downgrades of CDOs backed by subprime mortgages followed. The hardest hit were CDO-squareds, which in many cases defaulted and became virtually worthless offering no recoveries. As a result of these events, the rating agencies have faced heavy criticism for their assessment of risks of structured finance assets. Major banks and financial institutions have written down losses amounting to hundreds of billions of dollars on collateralized debt obligations and had to be saved by unprecedented actions of governments and central banks. The CDO markets have never recovered from their downfall during the 2007-09 financial crisis. The issuance of corporate CDOs has virtually disappeared from the financial markets, but some structures similar to CDOs such as tranches of mortgage-backed securities are still being issued although at a lower rate.

## 1.3 Overview of the Thesis

The remainder of the thesis consists of three research papers on credit securitization and credit derivatives that can be read independently. Chapter 2 focuses on rating and pricing of collateralized debt obligations. Chapter 3 examines determinants of CDS liquidity, while Chapter 4 is about relative pricing between equities and CDSs.

Chapter 2 of the thesis is directly motivated by the financial crisis. It investigates the relation between credit ratings and fair premia of CDO tranches and it also analyzes the risks of CDOs. Our main finding is that the market-standard models predict CDO

tranches to have much higher fair premia compared to similarly-rated corporate bonds implying that credit ratings are not sufficient for pricing, which is surprising given their central role in the structured finance markets. The explanation of this finding is that CDO tranches have much higher systematic risk than single-name instruments as losses on CDO tranches are concentrated in bad economic states. This can (partly) explain the very poor performance of CDO tranches during the recent crisis when even some of the previously AAA-rated tranches lost most of their value and were downgraded to junk within months. While the standard view is that the failure of CDOs was a result of insufficient or badly calibrated models used for assigning ratings to CDO tranches, we find that the essence of the problem lies with a fundamental difference between ratings and prices of these securities. The ratings are supposed to capture the real-world default probabilities, which for CDO tranches can indeed be low, but the market pricing of financial assets is based on risk-neutral probabilities that account for when the losses occur. The CDO tranches are instruments designed to take this difference to the limit and thus combine the highest credit ratings with the highest coupons possible. The downside is that such instruments carry greater risks because if they fail, they all fail at the same time. We also find that this effect is particularly strong for CDO-squareds, which are CDOs with a collateral pool comprised of other CDO tranches.

Chapter 3 investigates the determinants of the costs of trading in the corporate CDS market. The CDS market is well-standardized and thus offers a unique opportunity to investigate cross-sectional determinants of bid-ask spreads in an OTC credit market. We consider explanatory variables related to inventory costs and adverse selection costs following the broad equity literature on the costs of trading. We find that as much as 80% of variation in CDS bid-ask spreads is determined by proxies for dealer inventory costs such as variability of CDS premia or CDS trading volume. We also find that reference entities with lower idiosyncratic risks and thus less prone to insider trading have lower CDS bid-ask spreads ceteris paribus. Furthermore, we demonstrate that liquidity of CDS contracts is not significantly hindered by increased market volatility or funding costs as well as by information asymmetry associated with periods preceding earnings announcements. The CDS market thus appears to be robust and functioning orderly, which gives a positive view of the current CDS market structure dominated by a group of G-14 dealers.

Chapter 4 examines risks and returns of capital structure arbitrage strategies that aim to profit from temporal mispricing between equity and credit default swaps (CDSs) of companies. We demonstrate that implementing a simple version of this strategy offers an

attractive annualized return of 24.35% in the period from July 2010 to November 2012. We find that arbitrage returns are higher for lower rated companies and surprisingly they are also higher for more liquid companies with larger CDS trading volumes. This indicates that arbitrage profits are not merely driven by a lack of integration or synchronization of prices between these markets due to different levels of liquidity. In this chapter, we also demonstrate the importance of managing capital when implementing capital structure arbitrage because the number of open trades can cluster in time, which leads to large increases in capital needs. We find that an arbitrageur with insufficient capital would have to forgo the most profitable trading opportunities in our data period. Finally, we construct weekly return indices of capital structure arbitrage and we find that no more than 15% of the returns is explained by equity and bond risk factors, which suggests that capital structure arbitrage offers a different and potentially interesting risk-return exposure to investors.